Otakar Frank
J. Heyrovský Institute of Physical Chemistry, Czech Academy of Sciences, Dolejškova 2155/3, 182 23 Prague, Czech Republic

otakar.frank@jh-inst.cas.cz

(Nano)spectroscopic fingerprints of strong interactions between 2D layers and their substrate

Common spectroscopic investigation of two-dimensional materials and their van der Waals (vdW) heterostructures mostly relies either on diffraction-limited micro-Raman or photoluminescence (PL). However, these methods do not adequately capture local variations caused by, for example, nanometre-sized heterogeneities ensuing from contamination trapped between the layers or from intricate lattice deformation and charge-doping patterns caused by strong out-of-plane interactions.
Tip-enhanced spectroscopy techniques enable to gather information on the local lattice strain as well as on the interaction between the individual layers forming the heterostructure. What can appear as peak splitting in micro-Raman or PL spectra of vdW heterobilayers or transition metal dichalcogenides (TMDC) on metal substrates, may, actually, often stem from summing up signals from various regions within the laser spot, including new or discretely shifted peaks. In other cases, however, peak splitting can indicate lifting the degeneracy of the phonon, due to, for example, uniaxial deformation. Spectroscopic signatures, both on micro- and nanoscale, of variously interacting vdW layers will be discussed, including TMDCs on metals [1-3] and TMDC heterobilayers [4-6].

References

[1] Velický M., Rodriguez A., Bouša M., Krayev A.V., Vondráček M., Honolka J., Ahmadi M., Donnelly G.E., Huang F., Abruña H.D., Novoselov K.S., Frank O. The Journal of Physical Chemistry Letters 11 (2020) 6112.
[2] Velický M., Donnelly G.E., Hendren W.R., DeBenedetti W.J.I., Hines M.A., Novoselov K.S., Abruña H.D., Huang F., Frank O. Advanced Materials Interfaces 7 (2020) 2001324.
[3] Rodriguez A., Velický M., Řáhová J., Zólyomi V., Koltai J., Kalbáč M., Frank O. Physical Review B 105 (2022) 195413.
[4] Rodriguez A., Kalbac M., Frank O. 2D Materials 8 (2021) 025028.
[5] Rodriguez A., Krayev A., Velicky M., Frank O., El-Khoury P.Z. The Journal of Physical Chemistry Letters 13 (2022) 5854.
[6] Rodríguez Á., Varillas J., Haider G., Kalbáč M., Frank O. ACS Nano 17 (2023) 7787.